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WITNESS my hand this
Sixteenth day of October 2003

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PROVISIONAL SPECIFICATION

Invention Title: **"METHOD AND APPARATUS FOR DIAGNOSING MENTAL HEALTH"**

The invention is described in the following statement:

METHOD AND APPARATUS FOR ASSESSING MENTAL HEALTH

This invention relates to method and apparatus for assessing mental health. In particular it relates to the classification of text or speech in any language as an indicator for mental health status.

BACKGROUND TO THE INVENTION

At least 3% of the world population suffers from severe mental health problems including depression and schizophrenia. Mental health conditions such as schizophrenia, depression, etc are difficult to diagnose and treat. The success of treatment is enhanced if an early diagnosis is possible. Unfortunately, patients often do not seek treatment until the indicators of a mental health problem are pronounced. By the time treatment is sought the problem is chronic.

The known methods of assessing mental health conditions are subjective and rely upon the both the skill of the clinician and the honesty of responses of the patient. This latter point is particularly difficult to achieve since patients often minimize or disguise their symptoms and hence make accurate diagnosis difficult. Although questionnaires and screening tests exist, there is no reliable quantitative screening tool for schizophrenia.

It is known to use support vector machines (SVMs) for identification of the author of a document. The use of SVM was first described in: B. E. Boser, I. M. Guyon, and V. N. Vapnik. A training algorithm for optimal margin classifiers. In D. Haussler, editor, *5th Annual ACM Workshop on COLT*, pages 144-152, Pittsburgh, PA, 1992. ACM Press. SVMs have also been used for text analysis: Joachims, T.: Text Categorization with Support Vector Machines: Learning with Many Relevant Features. Proceedings of the Tenth European Conference on Machine Learning

(ECML '98), Lecture Notes in Computer Science, Number 1398 (pp. 137-142), 1998.

An ideal screening tool would be one that was an objective system that can operate without causing changes in, or influencing the behavior of the patient.

DISCLOSURE OF THE INVENTION

In one form, although it need not be the only or indeed the broadest form, the invention resides in a method of assessing a mental health problem including the steps of:

capture a text or speech sample that is indicative of thought processes or mood of a patient;

analyze the text or speech sample to determine a frequency of occurrence of words, syllables, phonemes or other symbols;

produce a data file containing data based upon the frequency of occurrence of the words, syllables, phonemes or other symbols;

submit the data file to one or more pre-taught machine learning algorithms;

combine output of the machine learning algorithms to determine the presence of a mental health problem.

The data file may contain the frequency of occurrence or a transformation of the frequency data.

The invention may further include the preliminary steps of teaching the machine learning algorithms by:

combining text or speech samples with classes of psychiatric disorders and symptom severity derived from clinical trials and clinical assessments to form the data file;

submitting the data file to the machine learning algorithms;

translating the internal representation of the machine learning algorithms into symbolic rules.

Suitably the machine learning algorithms include a support vector machine, a decision tree learning algorithm, and a neural network.

Suitably the invention may also include a learning method in which text or speech samples from patients known to have mental health problems and patients known not to have mental health problems are analyzed. In addition to the text and speech samples, an expert-defined mental health related category must be provided for learning purposes. This category can be discrete (presence or absence of the expert-defined mental health problem) or it can be a ranking on a given scale representing the severity of the mental health problem. An expert ranking of text or speech samples must be available for learning purposes if the invention is to operate in ranking mode.

In a further form the invention resides in an apparatus for diagnosing or assessing a mental health problem comprising:
means for capturing a sample of text or speech;
a processor programmed to analyse the sample and compile a data file of frequency of occurrence of words, syllables, phonemes or other symbols;

one or more machine learning algorithms programmed in the processor and producing an output indicative of mental health;
means for combining the outputs;

display means adapted to display the mental health problem or a lack of mental health problem.

BRIEF DESCRIPTION OF THE DRAWINGS

To assist in understanding the invention, preferred embodiments will be described with reference to the following figures in which:

FIG 1 shows a flowchart of a method of assessing mental health;

FIG 2 shows a flowchart of a learning phase that is preliminary to assessing mental health; and

FIG 3 shows a block diagram of an apparatus for working the method.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to FIG 1, there is shown a flowchart outlining the steps of a method for assessing mental health. The first step of the method is to obtain a sample of text or speech from a patient. The text or speech sample will be indicative of thought processes or the mood of the patient. Analysis of the sample leads to an indicator of the thought processes and hence an assessment of mental health.

If a speech sample is obtained it is preprocessed into a text block using known speech to text translation algorithms.

The text is processed to produce a datafile for machine analysis that contains the frequency of occurrence of each word or symbol in the sample. The data file is submitted to two or more machine learning techniques and the combination of the outputs of the machine learning techniques is obtained. Three machine learning techniques are used in a preferred form. A support vector machine is used as one of the machine learning techniques and decision tree learning and a neural network are the other two.

The combination of the output of the machine learning methods represents the diagnosis. These outputs are compared against psychiatric classification parameters and symptom severity measurements to validate them as diagnostic tools.

In order to work the invention in a diagnostic mode it must first be operated in a learning mode to build the association between the output and the text or speech sample. The learning process is shown in the flow chart of FIG 2.

The learning phase is conducted separately for each known mental health problem. The first step is to select a mental health problem, say depression, and to collect text or speech samples from patients known to

have that mental health problem (these are marked as positive samples). Samples are also obtained from people who are known not to have the problem (these are marked as negative samples). A sufficiently large data set must be available to guarantee the statistical validity of the method.

If the intended use of the system is classification (diagnosis), mark text or speech samples from authors/speakers with the expert-defined mental health problem as positive examples and all others as negative. If the intended use of the system is a ranking, obtain expert ranking with regard to mood and/or thought disorder for text or speech samples.

A ranked list of words or symbols according to frequency is generated from the corpus of all samples obtained (positives and negatives). The words are then formed into blocks of words or symbols of user-determined length.

For each block of words or symbols the frequency of occurrence of each word or symbol is recorded. A data file is generated from the frequency data for submission to two or more machine learning algorithms. In the preferred form of the invention, one of these machine learning algorithms is a support vector machine (SVM) as described in B. E. Boser, I. M. Guyon, and V. N. Vapnik. A training algorithm for optimal margin classifiers. In D. Haussler, editor, *5th Annual ACM Workshop on COLT*, pages 144-152, Pittsburgh, PA, 1992. ACM Press.

The machine learning techniques can be applied in any order. In case of SVM learning, each row in the datafile represents a block of words. It includes the class label [1 if this block is from an author/speaker with the mental health problem, -1 otherwise]. If the system is to produce a ranking, expert-ranking replaces the class label. This is followed by attribute-value pairs. Attributes are words represented by numbers (the ranking of the word in the corpus) plus the frequency of occurrence of the word in this block of text. The frequency may be normalized with regard to n (the block size).

The data file is submitted to the SVM so that it "learns" the difference between positives and negatives. Once trained the SVM will generate an output for an unknown text block that will be indicative of the presence or otherwise of the mental health problem.

During learning, the SVM adjusts parameters to approach the target outcome. The set of parameters that achieve the target outcome are saved in a model file. The model file is used to generate rules that become part of the diagnostic device.

The data file is translated to a suitable form for the second and subsequent machine learning algorithms. The inventor has found that good accuracy is obtained when three machine learning algorithms are used. By way of example, the other two algorithms may be a decision tree algorithm (DT) and a neural network algorithm (NN): Tickle, A.B.; Andrews, R.; Golea, M.; Diederich, J.: The truth will come to light: directions and challenges in extracting the knowledge embedded within trained artificial neural networks. IEEE Transactions on Neural Networks 9 (1998) 6, 1057-1068. When translating the data file for use by the decision tree algorithm or the neural network, it may be necessary to limit the number of attributes to the most frequent words only.

As with the SVM, the outputs from the DT and the NN will be indicative of the presence or otherwise of a mental health problem in the text or voice sample. The set of parameters (for example, weights in the case of the neural network) are used to generate rules that become part of the diagnostic device, as with the SVM rules discussed above. The rules (weights, parameters, etc) direct information flow through the machine learning algorithms in the diagnostic device.

The inventor has found that the accuracy of the invention is improved if a combination of the outputs of the machine learning techniques is used as the basis for diagnosis. The outputs can be combined in a variety of ways to achieve the best outcome. At the simplest level the outcomes may be combined in a simple vote. For

instance, if two algorithms diagnose a problem and one does not, the outcome would be considered as positive with respect to that problem. Other combination techniques, such as weighted averages, would also be suitable. In such a case the weighting may be derived from the relative effectiveness of each algorithm of assessing a given mental health problem.

Once the invention has been trained to recognize the difference between positives and negatives, rules are extracted to be used as a possible input to the invention in the diagnostic (classification or ranking) mode. The rule extraction may be performed for the SVM, DT and NN. Rule extraction from the DT is built-in, rule-extraction from the SVM proceeds by applying decision tree learning to the inputs and outputs of the SVM, and rule-extraction from NN is using one of the methods in Tickle, A.B.; Andrews, R.; Golea, M.; Diederich, J.: The truth will come to light: directions and challenges in extracting the knowledge embedded within trained artificial neural networks. IEEE Transactions on Neural Networks 9 (1998) 6, 1057-1068.

An apparatus suitable for working the method is depicted in FIG 3. A sample capture device captures text or speech samples from any suitable source. A text sample may be captured from an email, newsgroup message, letter, essay, poem, newspaper article, etc. If a voice sample is captured it is converted to a text sample using known voice to text translation algorithms. This may occur in the sample capture device or externally. Suitable voice samples maybe a telephone conversation, a public presentation, a clinical interview, etc.

The sample is passed to a processor that includes an analyzer that forms the data file of words and frequency. The data file may be generated in a number of different forms to suit the machine learning algorithms employed. The data file is then processed according to a rule set or using two or more machine learning algorithms. The rules may suitably be stored external from the processor.

The outputs from the algorithms are then combined. A diagnostic display, which may be graphic or text, is produced. The display may be visual or hard copy.

It will be appreciated that after successful completion of the learning phase the invention can be used to classify any text or voice sample of minimal length into one or more mental health related categories, including depression, mania, schizophrenia, aphasia, etc. The method can be used to assess a mental health problem based on a written document or a speech sample without the knowledge of the subject. This provides a completely objective assessment that cannot be biased by a patient.

It will further be appreciated that the invention is not limited to the diagnosis of a mental health problem when one is suspected. The invention can be used in a screening application to monitor the mental health of groups of subjects, for example key decision makers in government jobs. In particular, the method can be embedded in a search engine that ranks documents and audio files with regard to mood or thought disorder for a given combination of search items.

The inventors have found in preliminary testing that the invention can correctly classify a mental health problem with 84% accuracy after completion of the learning phase.

Throughout the specification the aim has been to describe the preferred embodiments of the invention without limiting the invention to any one embodiment or specific collection of features.

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INTERNATIONAL KNOWLEDGE DISCOVERY INSTITUTE PTY LTD

By their Patent Attorneys

FISHER ADAMS KELLY

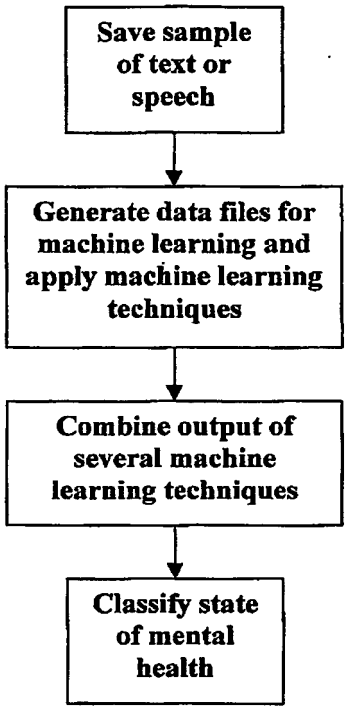
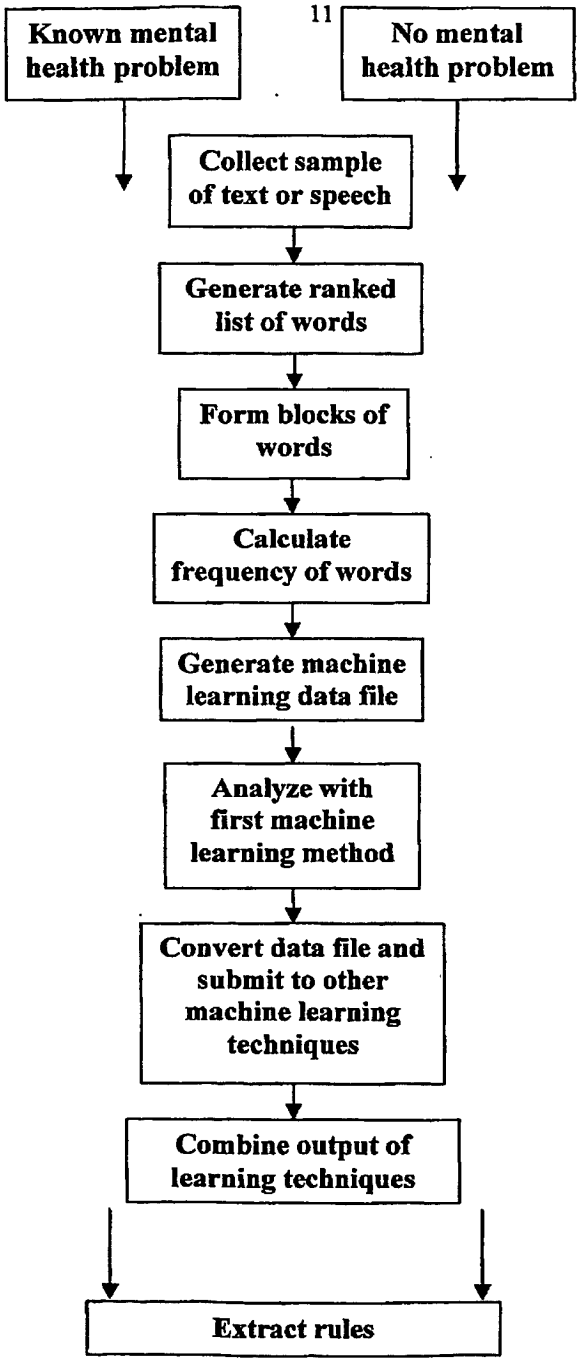

Save sample of text or speech
Generate data files for machine learning and apply machine learning techniques
Combine output of several machine learning techniques
Classify state of mental health

FIG 1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Known mental health problem
No mental health problem
Collect sample of text or speech
Generate ranked list of words
Form blocks of words
Calculate frequency of words
Generate machine learning data file
Analyze with first machine learning method
Convert data file and submit to other machine learning techniques
Combine output of learning techniques
Extract rules

FIG 2

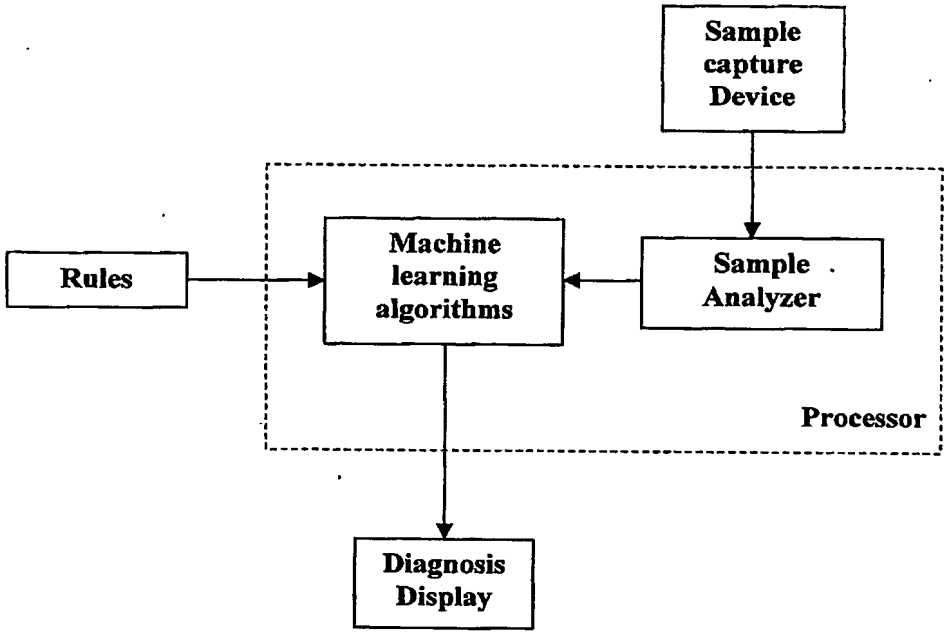
Sample capture Device
Rules
Machine learning algorithms
Sample Analyzer
Processor
Diagnosis Display

FIG 3